SOLAR/1050-79/05

Monthly Performance Report

BOND CONSTRUCTION

MAY 1979

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

MONTHLY PERFORMANCE REPORT

BOND CONSTRUCTION

MAY 1979

I. SYSTEM DESCRIPTION

The Bond Construction site is a single-family residence in Gladstone, Missouri. The home has approximately 1400 square feet of conditioned space. Solar energy is used for space heating the home and preheating domestic hot water (DHW). The solar energy system has an array of flat-plate collectors with a gross area of 465 square feet. The array faces south at an angle of 37 degrees to the horizontal. A propylene glycol solution is the transfer medium that delivers solar energy from the collector array to an external heat exchanger. Water is the transfer medium that delivers solar energy from the external heat exchanger to storage and from storage to the hot water load and liquid-to-air heat exchanger in the furnace. Air is the transfer medium that delivers solar energy to the space heating load. Solar energy is stored in the basement in an 800-gallon steel storage tank with walls approximately 1/4-inch thick. The storage tank has 4-inch polyurethane insulation on the bottom and 8-inch fiberglass insulation on the top and sides. Preheated city water is stored in an 82-gallon DHW tank. When solar energy is insufficient to satisfy the space heating load, a gas furnace provides auxiliary energy for space heating. Similarly, an electrical immersion heater in the DHW tank provides auxiliary energy for heating the supply water. Solar energy is transferred from the storage tank to the hot-air heating system by a liquid-to-air heat exchanger contained in the furnace ductwork; solar energy is transferred from the storage tank to the DHW tank by an annular heat exchanger jacket around the hot water tank. The house also contains a fireplace with an integral fan; the fireplace is only instrumented for monitoring fan power consumption. The system, shown schematically in Figure 1, has 5 modes of solar operation.

Mode 1 - Collector-to-Storage: This mode activates when there is a temperature difference of 20°F between a control sensor located at the collector and a control sensor located inside the storage tank (near the bottom). At this time the controller turns on both the collector and storage circuit

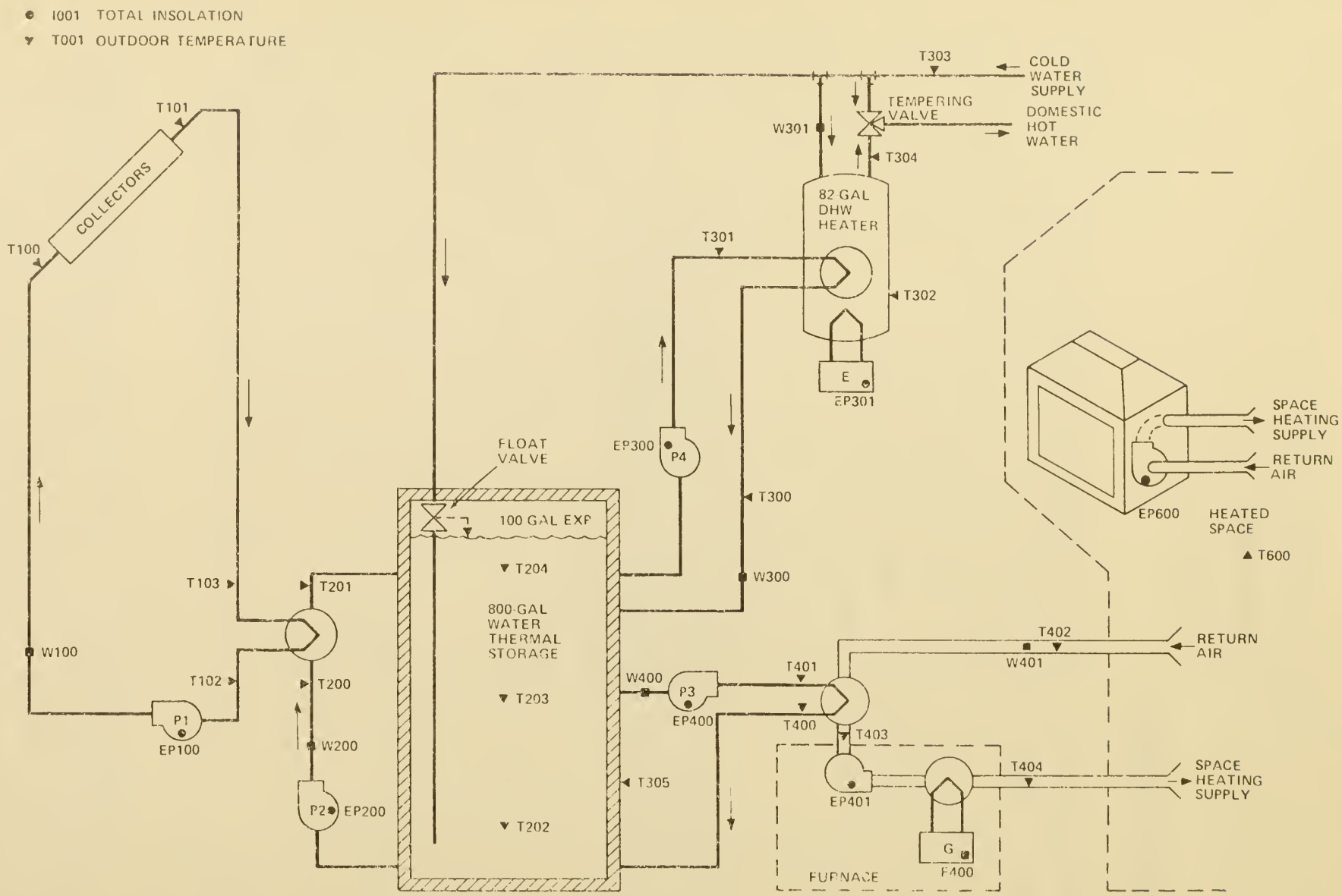

Figure 1. BOND CONSTRUCTION CO. SOLAR ENERGY SYSTEM SCHEMATIC

pumps (P1 and P2, respectively). Solar energy is transferred from the collector to the storage tank by an external heat exchanger. Both pumps continue to operate until the temperature difference is less than 5°F; the controller then turns both pumps off.

Mode 2 - Storage-to-Space Heating: This mode activates when the room temperature drops to the setting on the house thermostat. At this point, this mode is initiated if the storage temperature, measured by a control sensor inside the tank (near the top), is higher than 95°F. If so, the furnace circuit pump (P3) turns on and hot water circulates from the storage tank through a liquid-to-air heat exchanger in the furnace. At the same time the furnace fan turns on, forcing air past the heat exchanger, thereby transferring the solar energy to the heating load. If the room temperature drops an additional increment (set point), the auxiliary gas burner turns on to provide auxiliary energy to the heating load. If storage temperature falls to 90°F while in this mode, the mode terminates. However, the fan and gas furnace continue to supply energy until the thermostat demand is satisfied. If the storage temperature is below 95°F when the room thermostat calls for heat, this mode does not activate; auxiliary energy is then provided by the gas furnace. The pump, fan and burner (if on) are turned off when the room temperature exceeds the thermostat setting.

Mode 3 - Storage-to-DHW: This mode activates when there is a temperature difference of 10°F between the control sensor located inside the storage tank (near the top) and the control sensor located in the hot water tank (near the middle). This mode terminates when the temperature difference drops to 3°F. When this mode activates, pump P4 circulates hot water from the storage tank through an annular jacket surrounding the hot water tank; energy is thereby transferred to the water in the hot water tank. The electric immersion heater in the hot water tank turns on to provide auxiliary energy to the DHW if the temperature in the hot water tank drops below its thermostat setting.

Mode 4 - Elimination of Excess Heat in Summer: This mode activates when the storage tank temperature, as determined by an aquastat located in the tank, exceeds 180°F. At this time the collector and storage circuit pumps (P1 and

P2, respectively) are activated, thereby transferring energy from the storage tank to the collector by way of the external heat exchanger. This energy is then radiated from the collector to the atmosphere. This mode continues until the storage temperature drops below 180°F.

Mode 5 - Snow Removal in Winter: This mode activates when the collector and storage circuit pumps (P1 and P2) are manually switched on in order to melt the snow that has accumulated on the collector.

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was unoccupied in May and the solar energy system operated continuously during the month. Total solar energy collected was 25.7 million Btu and the total solar energy used was 2.5 million Btu or 10 percent of the collected energy. The change in stored energy was 0.34 million Btu and the total system losses amounted to 3.8 million Btu. Solar energy satisfied 96 percent of the space heating requirements. The solar energy system incurred an electrical energy expense of 0.23 million Btu and provided a fossil fuel energy savings of 0.34 million Btu. The control problem that caused intermittent cycling of mode 1 during periods of good insolation continued throughout the month. There was no hot water load in May because the water was turned off.

WEATHER CONDITIONS

During the month, total incident solar energy on the collector array was 25.7 million Btu for a daily average of 1780 Btu per square foot. This was above the estimated average daily solar radiation for this geographical area during May of 1712 Btu per square foot for a south-facing plane with a tilt of 37 degrees to the horizontal. The average ambient temperature

during May was 64°F the same as the long-term average. The number of heating degree-days for the month (based on a 65°F reference) was 98, as compared with the long-term average of 127. The number of cooling degree-days was 81, as compared with the long-term average of 99.

THERMAL PERFORMANCE

System - During May the solar energy system performed approximately the same as expected. The expected performance was determined from a modified f-chart analysis using measured weather and subsystem loads as input. Solar energy used by the system was estimated by assuming that all energy collected would be applied to the load. Actual solar energy used was 2.5 million Btu and was equal to the estimated 2.5 million Btu. System total solar fraction was 96 percent versus an estimated 100 percent.

Collector - The total incident solar radiation on the collector array for the month of May was 25.7 million Btu. During the period the collector loop was operating, the total insolation amounted to 7.5 million Btu. The total collected solar energy for the month of May was 4.2 million Btu, resulting in a collector array efficiency of 16 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 4.3 million Btu. Operating energy required by the collector loop was 0.17 million Btu. Mode 4 operation during the month resulted in 0.24 million Btu being rejected to the outside ambient via the collector array. This represents approximately 6 percent of the solar energy collected during the month.

Storage - Solar energy delivered to storage was 4.3 million Btu. There were 2.5 million Btu delivered from storage to the DHW and space heating subsystems. Energy loss from storage was 1.4 million Btu. This loss represented 33 percent of the energy delivered to storage. The storage efficiency was 67 percent: This is calculated as the ratio of the sum of the energy removed from storage and the change in stored energy, to the energy delivered to storage. The average storage temperature for the month was 156°°F.

DHW Load - The DHW subsystem consumed 2.3 million Btu of solar energy and no auxiliary electrical energy. There was no hot water load because the water was turned off during the entire month. Losses from the DHW subsystem were 2.3 million Btu. The DHW subsystem consumed a total of 0.054 million Btu of operating energy, resulting in an electrical energy expense of 0.054 million Btu. This subsystem is discussed further in the "Observations" section.

Space Heating Load - The space heating subsytem consumed 0.21 million Btu of solar energy and 0.004 million Btu of auxiliary thermal energy to satisfy a space heating load of 0.15 million Btu. The solar fraction of this load was 96 percent. Losses from the space heating subsytem were 0.059 million Btu. The space heating subsytem consumed a total of 0.013 million Btu of operating energy, resulting in an electrical energy expense of 0.002 million Btu and a fossil fuel energy savings of 0.34 million Btu.

OBSERVATIONS

Due to a defective controller, mode 1 cycled during periods of good insolation during the entire month. The grantee will replace this controller as soon as a replacement controller is available. While this cycling affected the collector performance, the higher-than-normal total incident solar energy on the collector array and the very low subsystem loads resulted in a buildup of stored energy in the storage tank this month. The average storage temperature for May was 156°F, compared to 117°F in April. Sometimes the temperature in the storage tank exceeded 180°F, resulting in activation of mode 4. (A maximum temperature of 188°F was recorded at T204.) During approximately 12 hours of mode 4 operation, 0.24 million Btu were rejected via the collector array to the outside ambient. Mode 4 operation consumed approximately 14 percent of the total operating energy required by the collector loop.

Anomalies in two of the three storage temperature sensors required that the storage temperature be based on the single operating sensor. Since this sensor measures the temperature at the top of the tank, the reported average storage temperature is probably higher than the true average storage temperature.

The flow sensor in the storage/DHW loop (W300) is defective. Therefore, the design flow of 3 gallons per minute was used to determine the amount of solar energy delivered from storage to the DHW subsystem during May. The operating energy consumed by the DHW subsystem during mode 3 was considered to be an electrical energy expense since there was no DHW load during the month; therefore, the solar energy transfer from storage to the DHW heater served no useful purpose. (The house was unoccupied and the water was turned off.)

The performance factors show that 4.3 million Btu of solar energy were input to storage during May, although only 4.2 million Btu were collected. Analysis shows an energy gain between the collector and the heat exchanger input. An analysis of temperature differentials in the collector loop during mode 1 indicates that temperature sensor T100 (collector input) may be reading high. The calibration of this sensor, and the other temperature sensors in the collector loop, should be checked to verify that accurate temperature measurements are being recorded.

Based on the average storage temperature for the month (156°F) and the average ambient temperature at the storage tank (82°F), the storage loss for May indicates an R-value of approximately 6 for the storage tank when the design value was R-27 or greater. There will be an investigation to determine whether the high storage losses are due to insulation problems or possible thermosiphoning in the collector loop.

ENERGY SAVINGS

The solar energy system provided a total fossil fuel energy savings of 0.34 million Btu and incurred an electrical energy expense of 0.23 million Btu. The DHW subsystem incurred an electrical energy expense of 0.054 million Btu, while the space heating subsystem provided a fossil fuel energy savings of 0.34 million Btu and incurred an electrical energy expense of 0.002 million Btu.

III. ACTION STATUS

The grantee will replace the collector controller in June. Boeing must resolve the instrumentation sensor anomalies and check the calibration of the collector loop temperature sensors on their next site visit. No site visit is scheduled at this time. There will be an investigation of the high storage losses.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: BOND CONSTRUCTION GLADSTONE, MISSOURI SOLAR/1050-79/05
REPORT PERIOD: MAY,1979

SITE/SYSTEM DESCRIPTION:
BOND CONSTRUCTION IS A SINGLE FAMILY DWELLING. THE SOLAR ENERGY SYSTEM PROVIDES SPACE HEATING AND HOT WATER. THE COLLECTION/HX LOOP USES A PROPYLENE GLYCOL SOLUTION AS AN ENERGY TRANSFER MEDIUM. THE HX/STORAGE LOOP USES WATER FOR ENERGY TRANSFER AND WATER IS THE STORAGE MEDIUM. THE STORAGE TANK PROVIDES SOLAR ENERGY FOR SPACE HEATING AND DHW THROUGH HX LOOPS. A GAS FURNACE PROVIDES AUXILIARY SPACE HEAT AS REQUIRED. AUXILIARY HEAT FOR THE DHW IS SUPPLIED ELECTRICALLY.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	25.688	MILLION BTU
	55195	BTU/SQ.FT.
COLLECTED SOLAR ENERGY	4.165	MILLION BTU
	8949	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	64	DEGREES F
AVERAGE BUILDING TEMPERATURE	73	DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.10	
ECSS OPERATING ENERGY	0.173	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	0.240	MILLION BTU
TOTAL ENERGY CONSUMED	5.032	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL	
LOAD	0.000	0.150	N.A.	0.150	MILLION BTU
SOLAR FRACTION	0	96	N.A.	96	PERCENT
SOLAR ENERGY USED	2.311	0.205	N.A.	2.515	MILLION BTU
OPERATING ENERGY	0.054	0.013	N.A.	0.240	MILLION BTU
AUX. THERMAL ENERGY	0.000	0.004	N.A.	0.004	MILLION BTU
AUX. ELECTRIC FUEL	0.000	N.A.	N.A.	0.000	MILLION BTU
AUX. FOSSIL FUEL	N.A.	0.627	N.A.	0.627	MILLION BTU
ELECTRICAL SAVINGS	-0.054	-0.002	N.A.	-0.229	MILLION BTU
FOSSIL SAVINGS	N.A.	0.341	N.A.	0.341	MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.105

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: BOND CONSTRUCTION GLADSTONE, MISSOURI SOLAR/1050-79/05
REPORT PERIOD: MAY,1979

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GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	27.100	GIGA JOULES
	626792	KJ/SQ.M.
COLLECTED SOLAR ENERGY	4.394	GIGA JOULES
	101624	KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	18	DEGREES C
AVERAGE BUILDING TEMPERATURE	23	DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.10	
ECSS OPERATING ENERGY	0.183	GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	0.253	GIGA JOULES
TOTAL ENERGY CONSUMED	5.309	GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	0.000	0.158	N.A.	0.158 GIGA JOULES
SOLAR FRACTION	0	96	N.A.	96 PERCENT
SOLAR ENERGY USED	2.438	0.216	N.A.	2.654 GIGA JOULES
OPERATING ENERGY	0.057	0.014	N.A.	0.253 GIGA JOULES
AUX. THERMAL ENG	0.000	0.005	N.A.	0.005 GIGA JOULES
AUX. ELECTRIC FUEL	0.000	N.A.	N.A.	0.000 GIGA JOULES
AUX. FOSSIL FUEL	N.A.	0.661	N.A.	0.661 GIGA JOULES
ELECTRICAL SAVINGS	-0.057	-0.002	N.A.	-0.242 GIGA JOULES
FOSSIL SAVINGS	N.A.	0.360	N.A.	0.360 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.105

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REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: BOND CONSTRUCTION GLADSTONE, MISSOURI SOLAR/1050-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.949	60	0.142	N	0.009	0.000	0.149
2	0.147	59	0.000	O	0.000	0.000	0.000
3	0.399	50	0.047	T	0.001	0.000	0.119
4	1.088	54	0.223		0.013	0.000	0.205
5	1.088	60	0.136	A	0.004	0.000	0.125
6	1.091	69	0.097	P	0.003	0.000	0.089
7	0.968	73	0.080	P	0.002	0.000	0.082
8	0.769	76	0.051	L	0.001	0.000	0.066
9	0.931	77	0.074	I	0.003	0.000	0.079
10	0.352	63	0.000	C	0.000	0.000	0.000
11	0.932	50	0.128	A	0.005	0.000	0.138
12	1.068	58	0.101	B	0.005	0.000	0.094
13	1.063	63	0.118	L	0.015	0.025	0.111
14	0.801	65	0.082	E	0.002	0.000	0.103
15	0.855	63	0.097		0.002	0.000	0.113
16	0.961	69	0.092		0.002	0.000	0.096
17	0.943	75	0.085		0.003	0.000	0.090
18	0.375	68	0.033		0.000	0.000	0.087
19	0.381	62	0.044		0.000	0.000	0.115
20	0.654	65	0.069		0.003	0.000	0.106
21	0.898	59	0.079		0.003	0.000	0.088
22	1.046	66	0.078		0.013	0.000	0.074
23	0.518	58	0.045		0.000	0.000	0.086
24	0.991	58	0.091		0.005	0.000	0.092
25	0.963	63	0.082		0.013	0.002	0.085
26	0.893	65	0.086		0.002	0.000	0.096
27	1.002	69	0.072		0.017	0.052	0.072
28	1.016	72	0.085		0.017	0.063	0.084
29	1.027	74	0.077		0.017	0.068	0.075
30	0.845	73	0.075		0.013	0.025	0.089
31	0.675	62	0.048		0.001	0.000	0.071
SUM	25.688	-	2.515	N.A.	0.173	0.235	-
AVG	0.829	64	0.081	N.A.	0.006	0.008	0.098
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: BOND CONSTRUCTION GLADSTONE, MISSOURI SOLAR/1050-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.949	0.536	0.300	67	0.316
2	0.147	0.000	0.000	59	0.000
3	0.399	0.025	0.029	52	0.074
4	1.088	0.809	0.377	60	0.346
5	1.088	0.235	0.240	67	0.221
6	1.091	0.187	0.208	75	0.190
7	0.968	0.168	0.204	77	0.210
8	0.769	0.043	0.050	78	0.065
9	0.931	0.153	0.166	81	0.178
10	0.352	0.002	0.004	73	0.010
11	0.932	0.331	0.234	53	0.251
12	1.068	0.313	0.195	67	0.183
13	1.063	0.518	0.138	71	0.130
14	0.801	0.135	0.113	72	0.141
15	0.855	0.095	0.089	70	0.104
16	0.961	0.118	0.130	73	0.135
17	0.943	0.197	0.200	80	0.212
18	0.375	0.000	0.000	73	0.000
19	0.381	0.019	0.029	66	0.076
20	0.654	0.193	0.124	72	0.189
21	0.898	0.196	0.171	63	0.190
22	1.046	0.435	0.119	75	0.114
23	0.518	0.000	0.000	60	0.000
24	0.991	0.369	0.196	65	0.198
25	0.963	0.439	0.083	73	0.086
26	0.893	0.157	0.127	74	0.142
27	1.002	0.528	0.162	77	0.161
28	1.016	0.444	0.132	83	0.130
29	1.027	0.499	0.165	81	0.160
30	0.845	0.314	0.119	81	0.141
31	0.675	0.074	0.064	66	0.095
SUM	25.688	7.532	4.165	-	-
AVG	0.829	0.243	0.134	70	0.162
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: BOND CONSTRUCTION GLADSTONE, MISSOURI SOLAR/1050-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.301	0.142	0.145	123	0.955
2	0.000	0.000	-0.042	130	1.000
3	0.033	0.047	-0.064	122	-0.486
4	0.404	0.223	0.166	126	0.963
5	0.224	0.136	0.061	147	0.875
6	0.199	0.097	0.047	157	0.720
7	0.169	0.080	-0.001	160	0.463
8	0.052	0.051	-0.076	154	-0.473
9	0.170	0.074	0.044	151	0.692
10	0.004	0.000	-0.074	149	-20.347
11	0.239	0.128	0.082	149	0.880
12	0.207	0.101	0.055	161	0.754
13	0.172	0.118	0.029	168	0.853
14	0.105	0.082	-0.021	168	0.581
15	0.082	0.097	-0.013	164	1.027
16	0.117	0.092	0.003	164	0.807
17	0.199	0.085	0.004	164	0.445
18	0.000	0.033	-0.088	158	1.000
19	0.025	0.044	-0.054	147	-0.424
20	0.126	0.069	0.033	145	0.808
21	0.158	0.079	0.042	151	0.764
22	0.152	0.078	0.069	161	0.967
23	0.000	0.045	-0.078	159	1.000
24	0.203	0.091	0.077	159	0.827
25	0.107	0.082	0.031	168	1.061
26	0.129	0.086	-0.014	168	0.557
27	0.173	0.072	0.021	172	0.541
28	0.139	0.085	-0.003	173	0.592
29	0.178	0.077	0.005	173	0.459
30	0.131	0.075	-0.005	172	0.535
31	0.061	0.048	-0.039	167	0.148
SUM	4.261	2.515	0.342	-	-
AVG	0.137	0.081	0.011	156	0.671
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: BOND CONSTRUCTION GLADSTONE, MISSOURI SOLAR/1050-79/05
REPORT PERIOD: MAY,1979

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR.OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.000	0	0.084	0.003	0.000	0.000	N	-0.003	N	60	140	0
2	0.000	0	0.000	0.000	0.000	0.000	O	0.000	O	60	140	0
3	0.000	0	0.000	0.000	0.000	0.000	T	0.000	T	60	140	0
4	0.000	0	0.166	0.004	0.000	0.000		-0.004		60	140	0
5	0.000	0	0.096	0.002	0.000	0.000	A	-0.002	A	60	140	0
6	0.000	0	0.097	0.002	0.000	0.000	P	-0.002	P	60	140	0
7	0.000	0	0.080	0.002	0.000	0.000	P	-0.002	P	60	140	0
8	0.000	0	0.048	0.001	0.000	0.000	L	-0.001	L	60	140	0
9	0.000	0	0.074	0.002	0.000	0.000	I	-0.002	I	60	140	0
10	0.000	0	0.000	0.000	0.000	0.000	C	0.000	C	60	140	0
11	0.000	0	0.128	0.004	0.000	0.000	A	-0.004	A	60	140	0
12	0.000	0	0.101	0.002	0.000	0.000	B	-0.002	B	60	140	0
13	0.000	0	0.118	0.002	0.000	0.000	L	-0.002	L	60	140	0
14	0.000	0	0.082	0.002	0.000	0.000	E	-0.002	E	60	140	0
15	0.000	0	0.097	0.002	0.000	0.000		-0.002		60	140	0
16	0.000	0	0.092	0.002	0.000	0.000		-0.002		60	140	0
17	0.000	0	0.085	0.002	0.000	0.000		-0.002		60	140	0
18	0.000	0	0.033	0.001	0.000	0.000		-0.001		60	140	0
19	0.000	0	0.044	0.002	0.000	0.000		-0.002		60	140	0
20	0.000	0	0.069	0.002	0.000	0.000		-0.002		60	140	0
21	0.000	0	0.079	0.002	0.000	0.000		-0.002		60	140	0
22	0.000	0	0.078	0.001	0.000	0.000		-0.001		60	140	0
23	0.000	0	0.045	0.001	0.000	0.000		-0.001		60	140	0
24	0.000	0	0.091	0.002	0.000	0.000		-0.002		60	140	0
25	0.000	0	0.082	0.002	0.000	0.000		-0.002		60	140	0
26	0.000	0	0.086	0.002	0.000	0.000		-0.002		60	140	0
27	0.000	0	0.072	0.001	0.000	0.000		-0.001		60	140	0
28	0.000	0	0.085	0.001	0.000	0.000		-0.001		60	140	0
29	0.000	0	0.077	0.001	0.000	0.000		-0.001		60	140	0
30	0.000	0	0.075	0.001	0.000	0.000		-0.001		60	140	0
31	0.000	0	0.048	0.001	0.000	0.000		-0.001		60	140	0
SUM	0.000	-	2.311	0.054	0.000	0.000	N.A.	-0.054	N.A.	-	-	0
AVG	0.000	0	0.075	0.002	0.000	0.000	N.A.	-0.002	N.A.	60	140	0
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: BOND CONSTRUCTION GLADSTONE, MISSOURI SOLAR/1050-79/05
REPORT PERIOD: MAY, 1979

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.043	100	0.058	0.003	0.000	N	0.023	-0.001	0.096	68	60
2	0.000	0	0.000	0.000	0.000	O	0.015	0.000	0.000	68	59
3	0.035	89	0.047	0.003	0.003	T	0.018	-0.001	0.079	65	50
4	0.044	99	0.057	0.004	0.000		0.028	-0.001	0.096	66	54
5	0.027	100	0.039	0.002	0.000	A	0.022	-0.000	0.065	68	60
6	0.000	0	0.000	0.000	0.000	P	0.008	0.000	0.000	73	69
7	0.000	0	0.000	0.000	0.000	P	0.025	0.000	0.000	77	73
8	0.000	0	0.003	0.000	0.000	L	0.026	-0.000	0.005	81	76
9	0.000	0	0.000	0.000	0.000	I	0.019	-0.000	0.000	82	77
10	0.000	0	0.000	0.000	0.000	C	0.020	-0.000	0.000	80	63
11	0.000	0	0.000	0.000	0.000	A	0.015	0.000	0.000	69	50
12	0.001	0	0.000	0.000	0.001	B	0.010	-0.000	0.000	67	58
13	0.000	0	0.000	0.000	0.000	L	0.012	0.000	0.000	68	63
14	0.000	0	0.000	0.000	0.000	E	0.023	-0.000	0.000	67	65
15	0.000	0	0.000	0.000	0.000		0.021	0.000	0.000	61	63
16	0.000	0	0.000	0.000	0.000		0.014	-0.000	0.000	71	69
17	0.000	0	0.000	0.000	0.000		0.023	-0.000	0.000	76	75
18	0.000	0	0.000	0.000	0.000		0.019	-0.000	0.000	76	68
19	0.000	0	0.000	0.000	0.000		0.015	-0.000	0.000	73	62
20	0.000	0	0.000	0.000	0.000		0.022	-0.000	0.000	73	65
21	0.000	0	0.000	0.000	0.000		0.019	-0.000	0.000	72	59
22	0.000	0	0.000	0.000	0.000		0.023	0.000	0.000	72	66
23	0.000	0	0.000	0.000	0.000		0.020	0.000	0.000	72	58
24	0.000	0	0.000	0.000	0.000		0.022	0.000	0.000	70	58
25	0.000	0	0.000	0.000	0.000		0.023	0.000	0.000	71	63
26	0.000	0	0.000	0.000	0.000		0.024	-0.000	0.000	74	65
27	0.000	0	0.000	0.000	0.000		0.022	0.000	0.000	75	69
28	0.000	0	0.000	0.000	0.000		0.028	0.000	0.000	78	72
29	0.000	0	0.000	0.000	0.000		0.020	0.000	0.000	82	74
30	0.000	0	0.000	0.000	0.000		0.030	0.000	0.000	79	73
31	0.000	0	0.000	0.000	0.000		0.019	0.000	0.000	73	62
SUM	0.150	-	0.205	0.013	0.004	N.A.	0.627	-0.002	0.341	-	-
AVG	0.005	96	0.007	0.000	0.000	N.A.	0.020	-0.000	0.011	73	64
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: BOND CONSTRUCTION GLADSTONE, MISSOURI SOLAR/1050-79/05
REPORT PERIOD: MAY, 1979

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	2038	N	60	67	N	N	N
2	315	O	59	59	O	O	O
3	857	T	50	52	T	T	T
4	2337		54	60			
5	2337	A	60	67	A	A	A
6	2343	P	69	75	P	P	P
7	2081	P	73	77	P	P	P
8	1652	L	76	78	L	L	L
9	2001	I	77	81	I	I	I
10	757	C	63	73	C	C	C
11	2003	A	50	53	A	A	A
12	2294	B	58	67	B	B	B
13	2283		63	71			
14	1720	L	65	72	L	L	L
15	1837	E	63	70	E	E	E
16	2065		69	73			
17	2027		75	80			
18	807		68	73			
19	818		62	66			
20	1406		65	72			
21	1929		59	63			
22	2248		66	75			
23	1113		58	60			
24	2130		58	65			
25	2069		63	73			
26	1919		65	74			
27	2153		69	77			
28	2183		72	83			
29	2207		74	81			
30	1816		73	81			
31	1450		62	66			
SUM	55195	N.A.	-	-	-	-	-
AVG	1780	N.A.	64	70	N.A.	N.A.	N.A.
NBS ID	Q001		N113			N115	N114

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